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Strategies for a low carbon building stock in Germany

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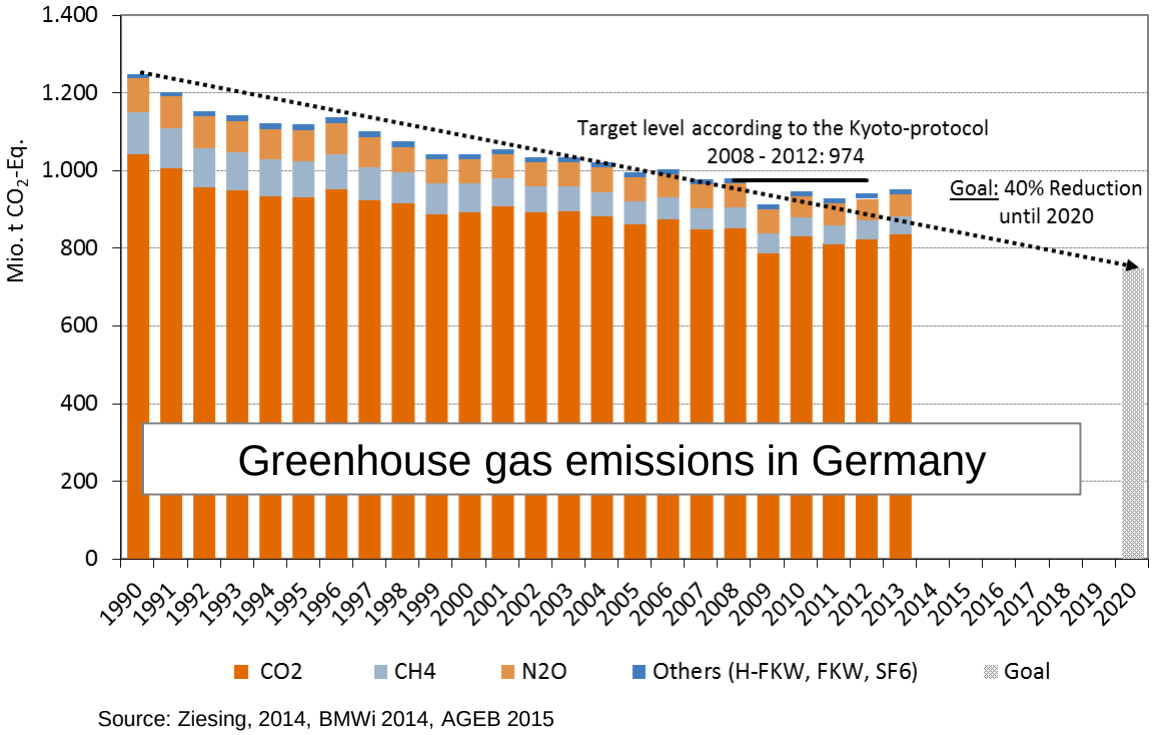
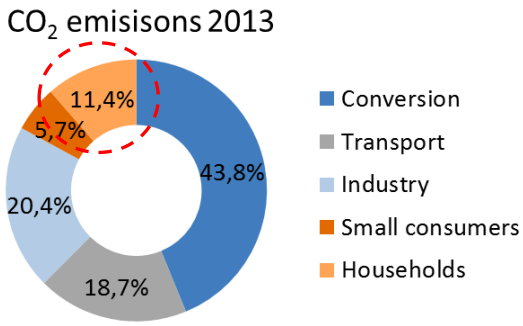
Outline

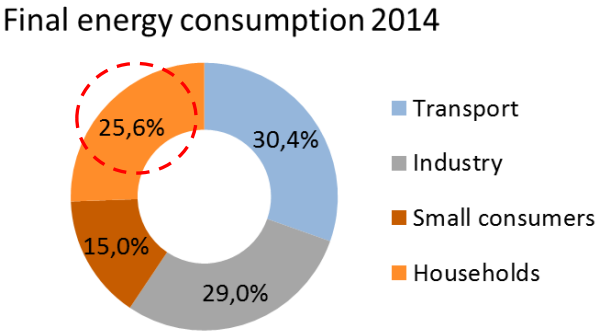
- Current status of energy efficiency of buildings – Some facts
- The German energy concept – Focus: Buildings
- Different Strategies and scenarios – Definition and assumptions
- Results
- Conclusions

The role of buildings



Source: Ziesing, 2014, BMWi 2014, AGEB 2015

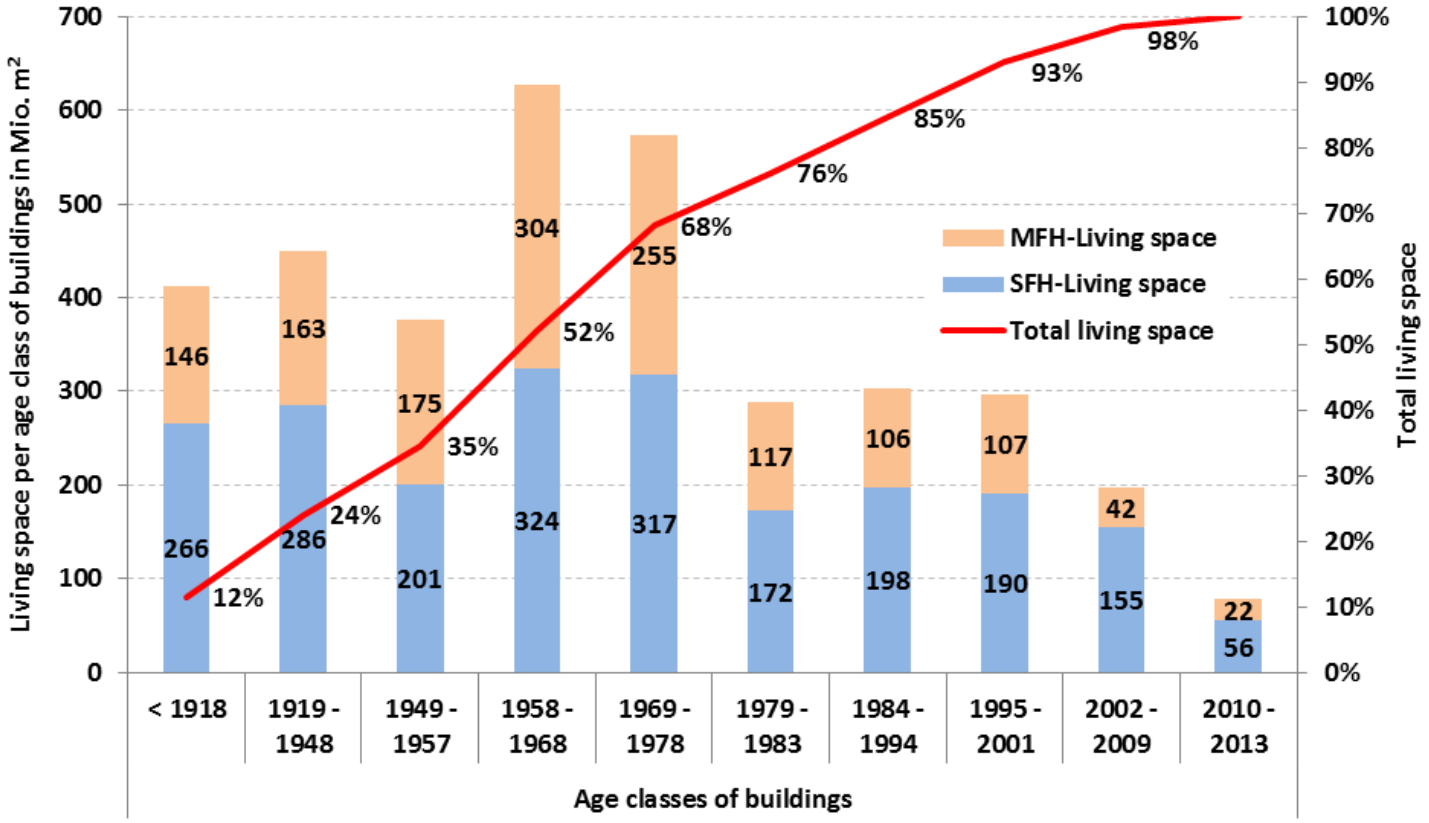




- Buildings account for about 37,6 % of national final energy consumption
  (Industry: 3,4%, Small consumers: 10,5%, Residential Buildings: **23,8%**)
- CO_2 emissions of residential buildings: 11,4% (≈ 100 Mio. t)

German residential building stock 2013

(18.5 Million Buildings)

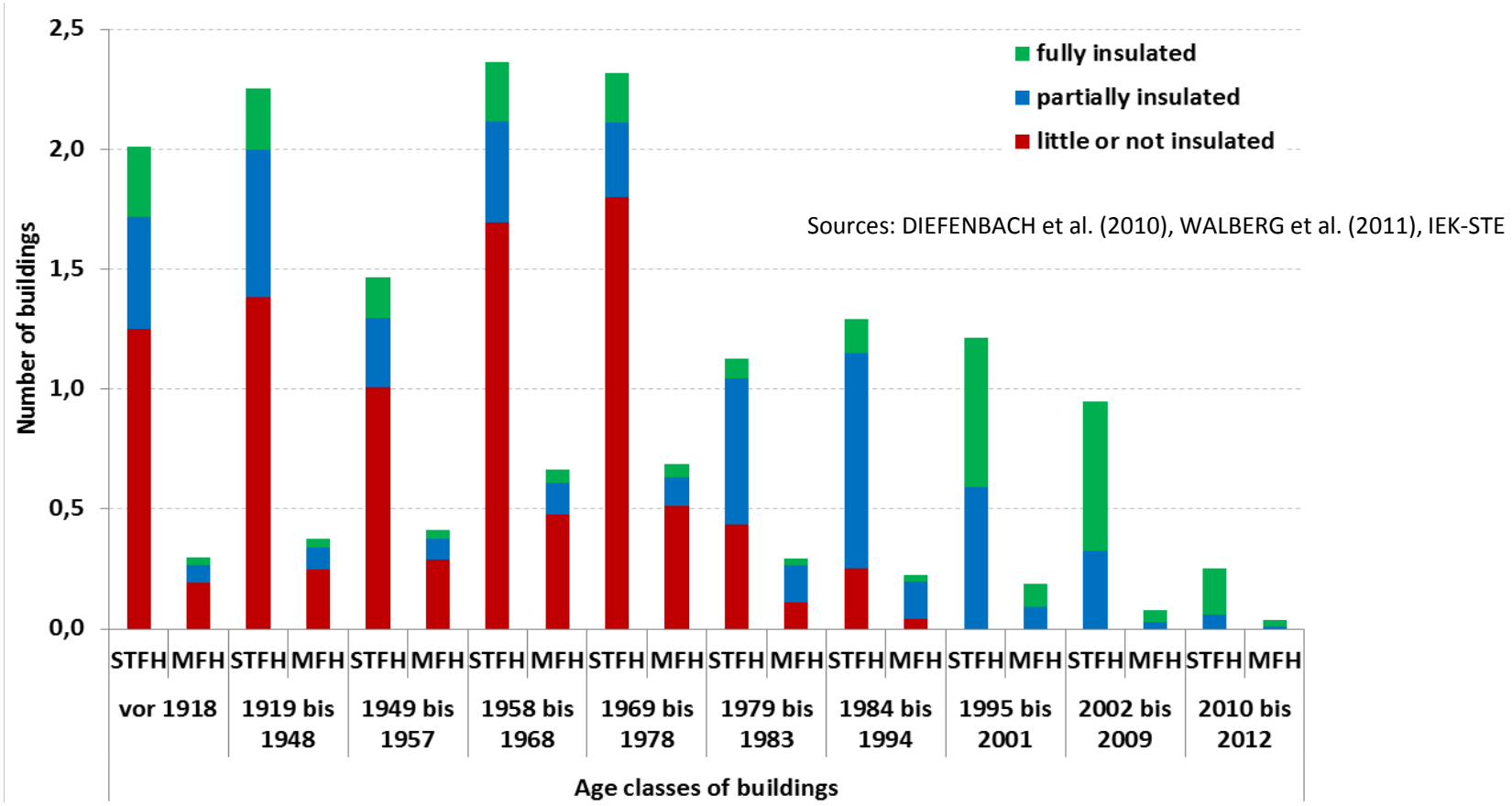


Sources: Destatis (2014), IWU (2013), IEK-STE

68% of Germany's existing building stock was built before the first heat insulation ordinance was adopted in 1979.

Insulation of residential buildings

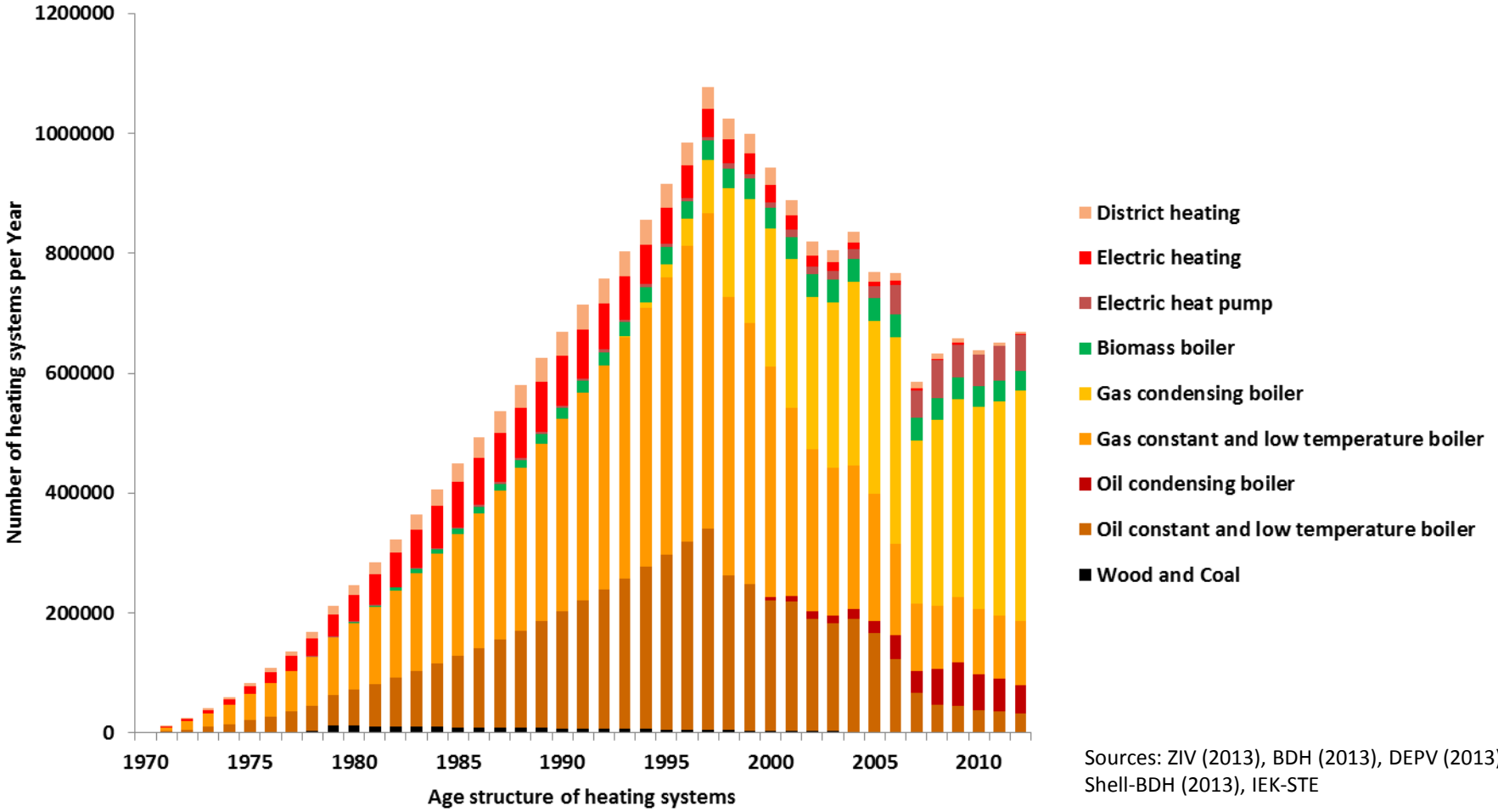
2013: 15.4 Single- and Two-Family Houses (STFH),
3.1 Mio. Multi-family houses (MFH)



➡ 50% of the residential buildings have insufficient insulation and another 30% have only a little or not insulated building envelope.

Stock of heating systems 2013

(Total: 23.2 Mio. centralized and additional heating systems)



Sources: ZIV (2013), BDH (2013), DEPV (2013), Shell-BDH (2013), IEK-STE

Around 50% of the heating systems are older than 24 years. The overwhelming majority of heating systems lag behind the state of the art.

The German energy concept

National CO_2-reduction goals[1)]: - 40% (2020) - 80% (2050)

1) compared to 1990

„Energy efficient refurbishment of existing buildings is the central key to modernise energy supply and to the achievement of climate change targets“ (National energy concept)

- Decrease of primary energy demand by 80% (compared to 2008)
- Reduction of heat demand by 20% until 2020
- Ensuring all **new** buildings are climate neutral by 2020 (EPBD)
- Increase of the (energetic) retrofit rate from 0.8% to 2% per year

➡ Favored by the government: **Energy efficiency improvement**

Most cost efficient strategy ? Other strategies ?

Definition of strategies (time horizon: 2013-2050)

	BaU	Thermal insulation (TI)	Modern heating systems (MHS)
Policy instruments	Update of existing policy instruments	Update and new policy instruments	Update and new policy instruments
Energy efficiency standards	Existing buildings EnEV2014 New buildings EPBD 2010 (nearly zero-energy from 2020) EEWärmeG	Existing buildings Tighter requirements until 2020/2030: +30%) New buildings Same as BaU	Existing buildings BaU and EEWärmeG New buildings Same as BaU
Refurbishment rate of building envelope	1%/a, from 2020: increase to 1,5%/a until 2050	Doubling the current rate up to 2%/a from 2020	Same as BaU
Replacement rate of heating systems	4%/a	Same as BaU	5%/a and increased use of modern heating systems, more renewable gas etc.

EnEV: Energy saving ordinance, EPBD: European Building Directive, EEWärmeG: Renewable energies heat act

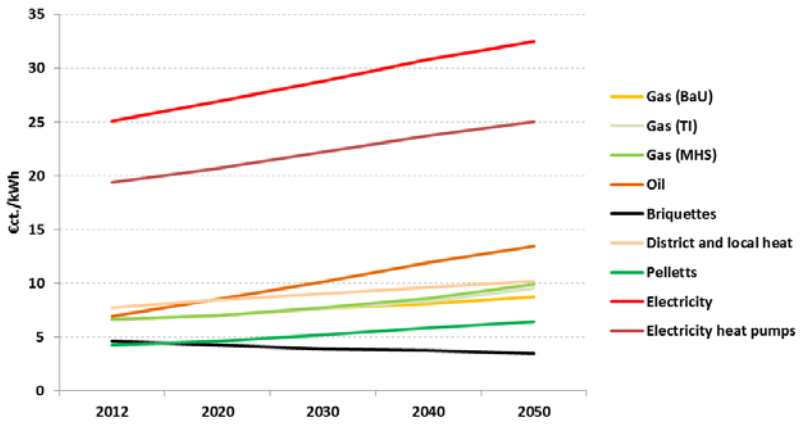
Key assumptions and methodology

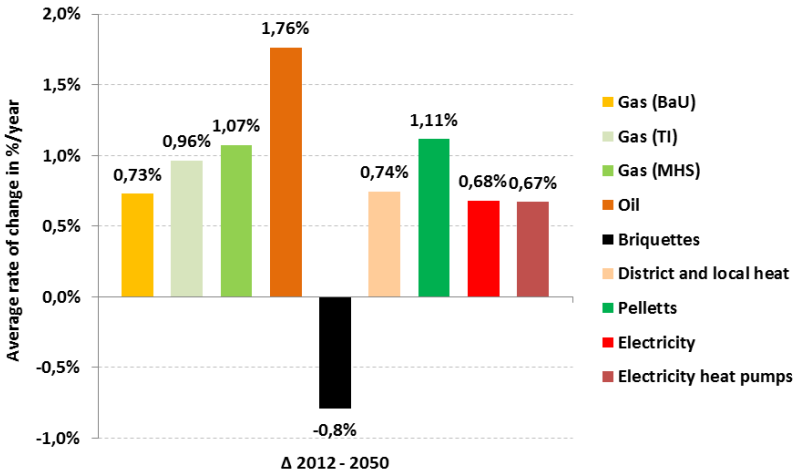
		2012	2050	Δ
Population	(Million)	80,5	69,4	-13,7%
Households	(Million)	40,7	37,7	- 7,3%
Living space	(billion m^2)	3,62	3,87	+7%
Living space per capita	(m^2/cap)	44,7	55,8	+24,8%
New construction	(billion m^2)	0	0,87	-
Demolishing	(billion m^2)	0	- 0,62	-

Methodology

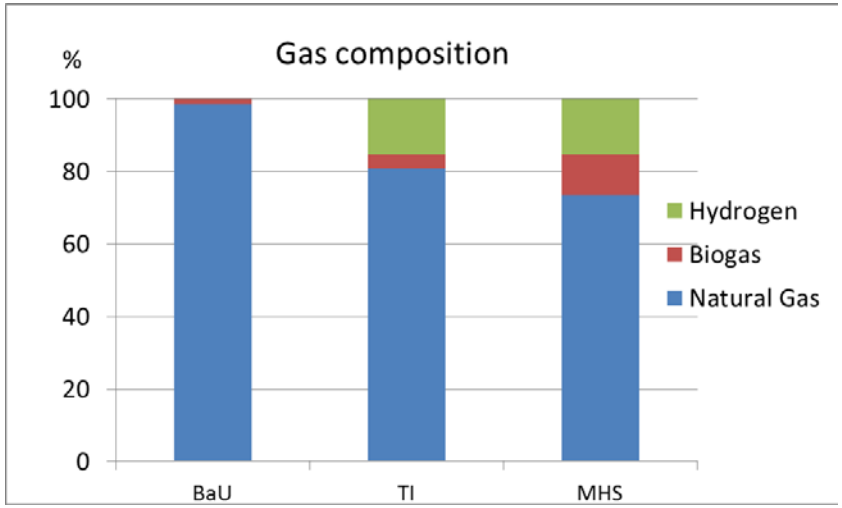
- Dynamic bottom up model JEMS-BTS (**B**uilding stock **T**echnology **S**imulation)
- Simulation of heat and hot water consumption, technology diffusion
- Building types (age, size, type,…) representing the national building stock (vintage approach)
- Time horizon: until 2050, yearly steps

Increase of energy prices





More Renewables (e.g. gases)

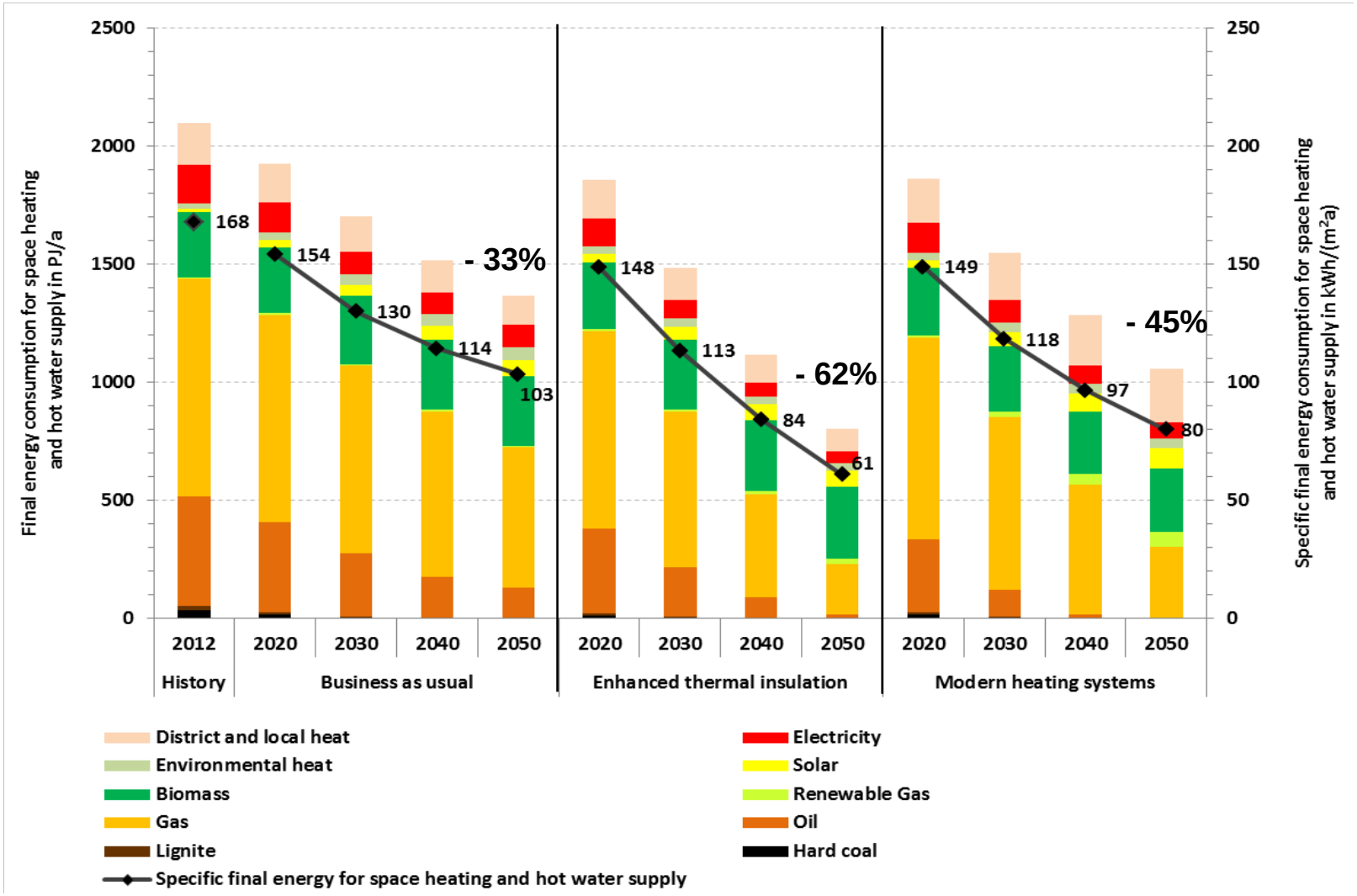


Modern heating systems

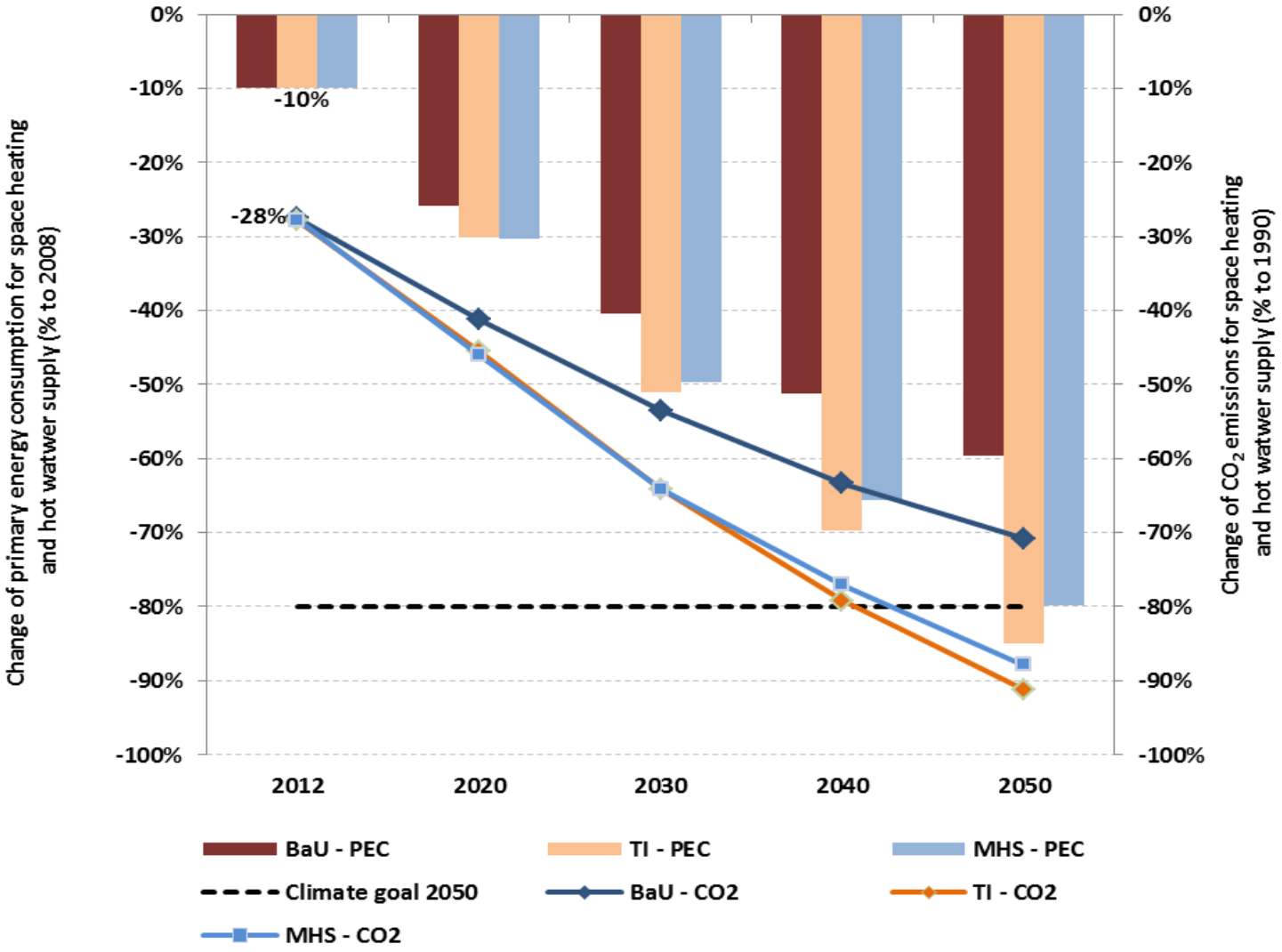
Conventional heating systems are substituted by

- Small CHP systems
- Heat pumps
- Thermal solar systems
- …

Results – Final energy demand



Results – Primary energy and CO_2-emission



Results – Costs

(cumulated values 2013 – 2050)	BaU	Enhanced thermal insulation (TI)		Modern heating systems (MHS)	
	absolute values	absolute values	Δ to BaU	absolute values	Δ to BaU
▪ **Additional Investment Costs (bn €)**	**443**	617	**174**	515	**72**
→ Heating systems (stock)	270	270	0	343	73
→ Heating systems (new buildings)	40	39	-1	39	-1
→ Heat insulation (stock)	87	262	175	87	0
→ Heat insulation (new buildings)	46	46	0	46	0
▪ **Energy costs (bn €)**	**802**	703	**- 99**	755	**- 47**
▪ **Net additional costs (bn €)**	**1.245**	1.320	**75**	1.270	**25**
▪ **CO_2 emissions (Million tCO_2)**	2.364	1.889	-475	1.919	-445
▪ **Specific reduction costs (€/tCO_2)**			**158**		**58**

Cumulated investments for building insulation (exisiting building stock), 2013 - 2050

(10^9 €)	Business as Usual (BaU)	Enhanced thermal insulation (TI)	Modern heating systems (MHS)
roofs	29,4	91,4	29,4
facades	44,4	96,9	44,4
cellars	6,3	10,5	6,3
windows	6,4	63,1	6,4
Total	*86,6*	*261,9*	*86,6*
	Cost difference compared with Business as usual		
roofs		61,9	0,0
facades		52,5	0,0
cellar		4,2	0,0
windows		56,7	0,0
Total		*175,3*	*0,0*

Average value in 2050: 103 kWh/m^2 a | 61 kWh/m^2 a | 80 kWh/m^2 a

Comparison: Today´s average value (all residential building types): 170 kWh/m^2 a

Conclusions

- Primary energy reduction goal of 80% until 2050 (compared to 2008) will be achieved with both strategies (TI and MHS)
- All strategies (also BaU) are ambitious (renovation cycle!)
- Significant cost advantages of a “hybrid” strategy (not only focusing on energy efficiency)
- Sensitivity analysis: results are robust
- Heat insulation is a key element in all strategies, but suitable weighting of more technical measures leads to lower costs

Thank you for your attention!

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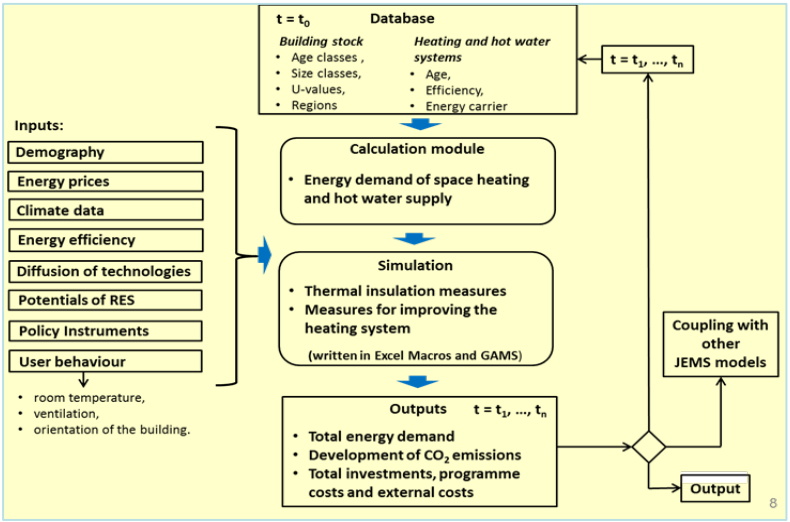
Backup

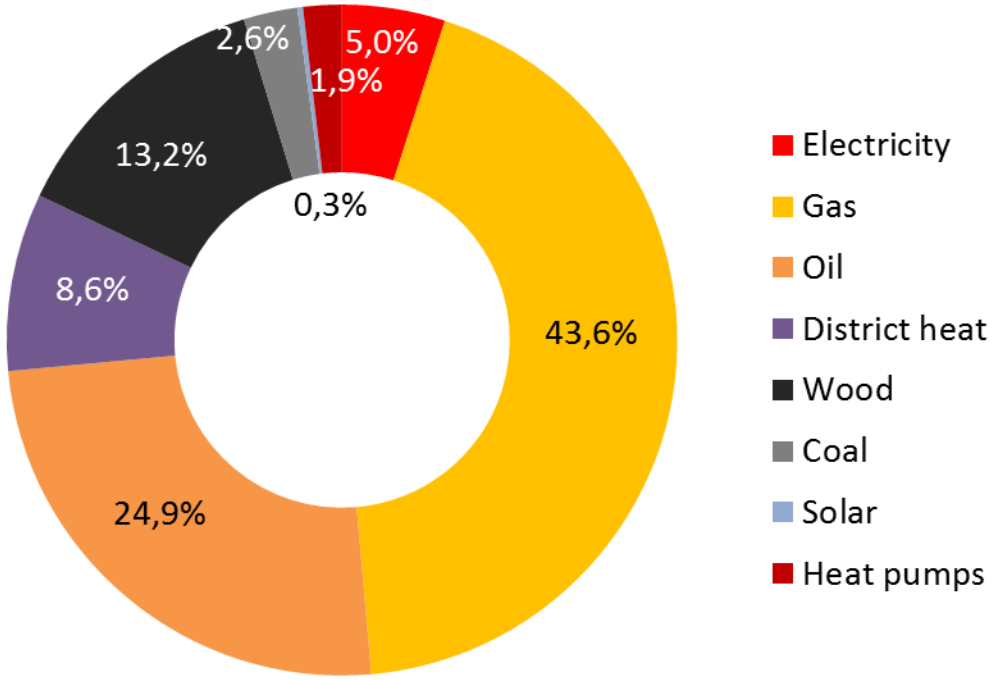
JEMS-BTS Model

- ***Type***: vintage simulation approach
- ***Input parameters***
  - Technology: building stocks, heating/ hot water, efficiency measures
  - Cost: technology, efficiency measures, energy
  - Macro-level: population, households, demand
- ***Simulation***
  - Measures: heating system, thermal insulation
  - Technology diffusion: adoption times
- ***Results***

  (regional resolution: admin. districts, Nuts-level 3)
  - Installed heating and hot water systems, insulation level
  - Energy demand (PE, FE)
  - CO_2 emissions
  - Costs (over strategy): capex, opex, energy (optional: environmental cost)



Energy demand for space heating and hot water in 2012 (Residential buildings)



Source: AGEB 2015

Gas and oil are the most important energy sources for space heating and hot water production. The share amounts to 68,5%